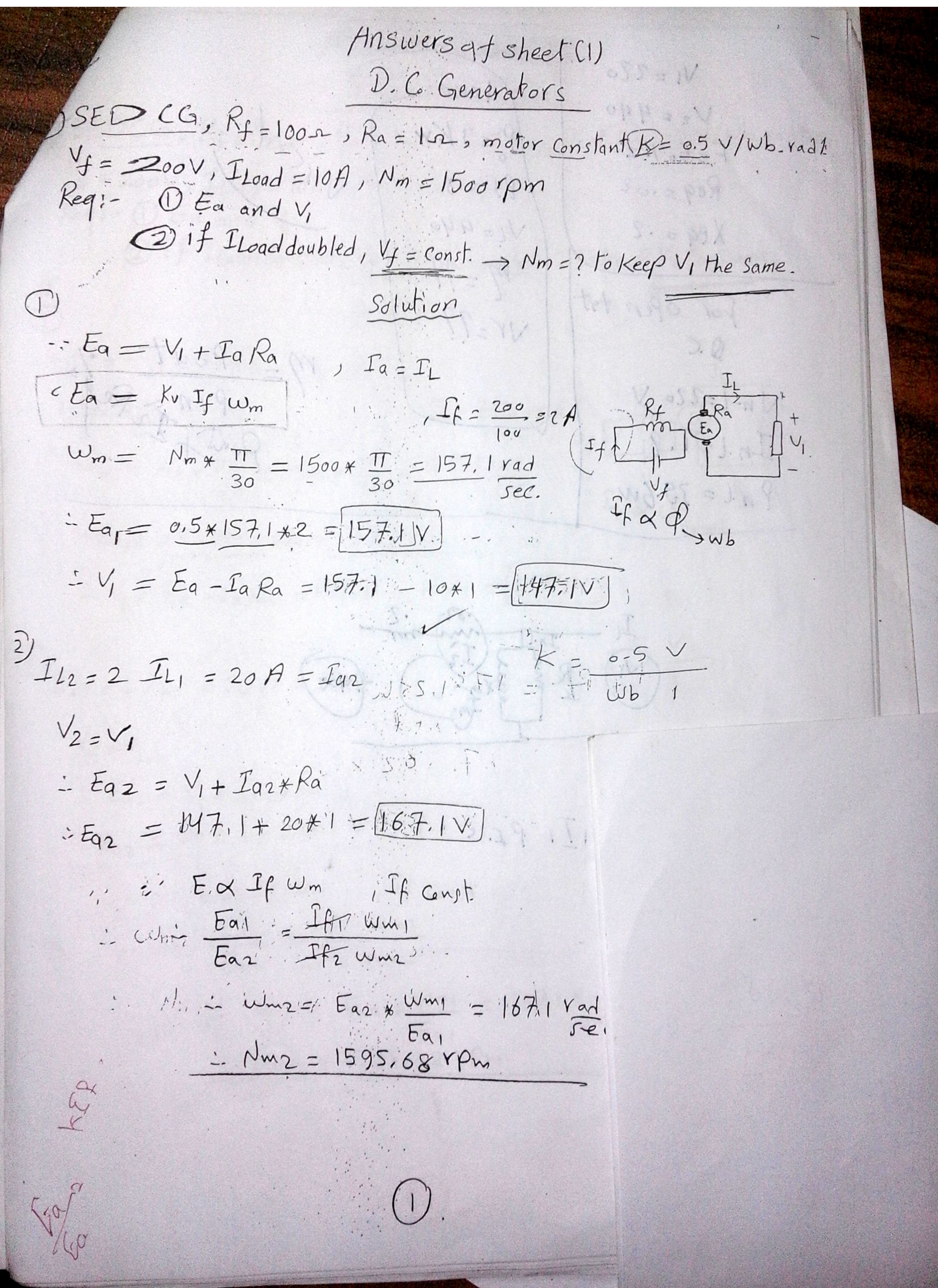


Answers of sheet (1)
D. C. Generators

1) SEDCG, $R_f = 100\Omega$, $R_a = 1\Omega$, motor constant $K = 0.5$ V/wb.rad/s

$V_f = 200V$, $I_{Load} = 10A$, $N_m = 1500$ rpm

Req:- ① E_a and V_1

② if I_{Load} doubled, V_f = const. → N_m = ? to keep V_1 the same.

Solution

①

$\because E_a = V_1 + I_a R_a$, $I_a = I_L$

$E_a = K_v I_f \omega_m$, $I_f = \frac{200}{100} = 2A$

$\omega_m = N_m * \frac{\pi}{30} = 1500 * \frac{\pi}{30} = 157.1 \frac{rad}{sec.}$

$I_f \propto \phi \rightarrow wb$

$\therefore E_{a_1} = 0.5 * 157.1 * 2 = 157.1V$

$\therefore V_1 = E_a - I_a R_a = 157.1 - 10*1 = 147.1V$

2)

$I_{L2} = 2 I_{L1} = 20A = I_{a2}$

$K = \frac{0.5 \ V}{wb \ 1}$

$V_2 = V_1$

$\therefore E_{a2} = V_1 + I_{a2} * R_a$

$\therefore E_{a2} = 147.1 + 20*1 = 167.1V$

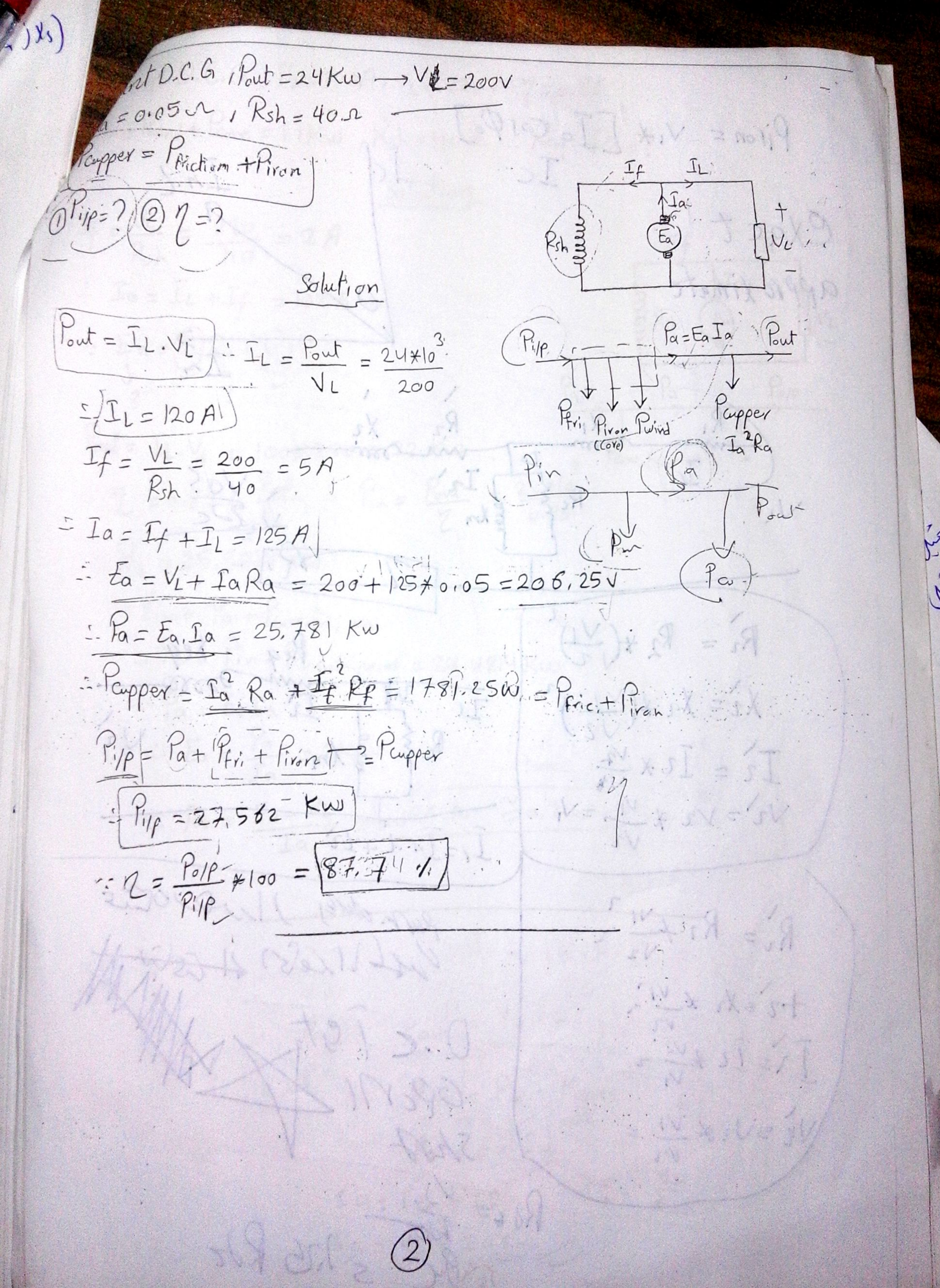
$\because E \propto I_f \omega_m$, I_f Const.

$\therefore \frac{E_{a1}}{E_{a2}} = \frac{I_{f1} \omega_{m1}}{I_{f2} \omega_{m2}}$

$\therefore \omega_{m2} = E_{a2} * \frac{\omega_{m1}}{E_{a1}} = 167.1 \frac{rad}{sec}$

$\therefore N_{m2} = 1595.68$ rpm

60/60



...nt D.C.G , $P_{out} = 24\,Kw \rightarrow V_L = 200V$

...$a = 0.05\,\Omega$, $R_{sh} = 40\,\Omega$

$P_{cupper} = P_{friction} + P_{iron}$

① $P_{i/p} = ?$ ② $\eta = ?$

Solution

$P_{out} = I_L \cdot V_L$ ∴ $I_L = \frac{P_{out}}{V_L} = \frac{24 * 10^3}{200}$

∴ $I_L = 120\,A$

$I_f = \frac{V_L}{R_{sh}} = \frac{200}{40} = 5A$

∴ $I_a = I_f + I_L = 125\,A$

∴ $E_a = V_L + I_a R_a = 200 + 125 * 0.05 = 206.25\,V$

∴ $P_a = E_a \cdot I_a = 25.781\,Kw$

∴ $P_{cupper} = I_a^2 R_a + I_f^2 R_f = 1781.25\,W = P_{fric} + P_{iron}$

$P_{i/p} = P_a + P_{fri} + P_{iron} \rightarrow = P_{cupper}$

∴ $P_{i/p} = 27.562\,Kw$

∴ $\eta = \frac{P_{o/p}}{P_{i/p}} * 100 = 87.74\,\%$

...unt D.C.G., $I_L = 100A$, $V_L = 220V$, $\eta = 0.86$

$P_{fri} + P_{wind} + P_{core} = 1.1\,Kw$, $R_{sh} = 110\,\Omega$ ... Req1 $R_a = ?$

Solution

$$I_f = \frac{V_L}{R_{sh}} = \frac{220}{110} = 2A$$

$\therefore I_a = I_L + I_f = 102A$

$\because E_a = I_a R_a + V_L$

E_a ↓ ?, I_a ✓, R_a ↓ ?, V_L ✓

$P_{out} = I_L \cdot V_L = 100 * 220 = 22\,Kw$

$$\because \eta = 0.86 = \frac{P_{out}}{P_{in}} \therefore P_{in} = \frac{P_{out}}{\eta} = \frac{22*10^3}{0.86}$$

$\therefore P_{in} = 25.5814\,Kw$

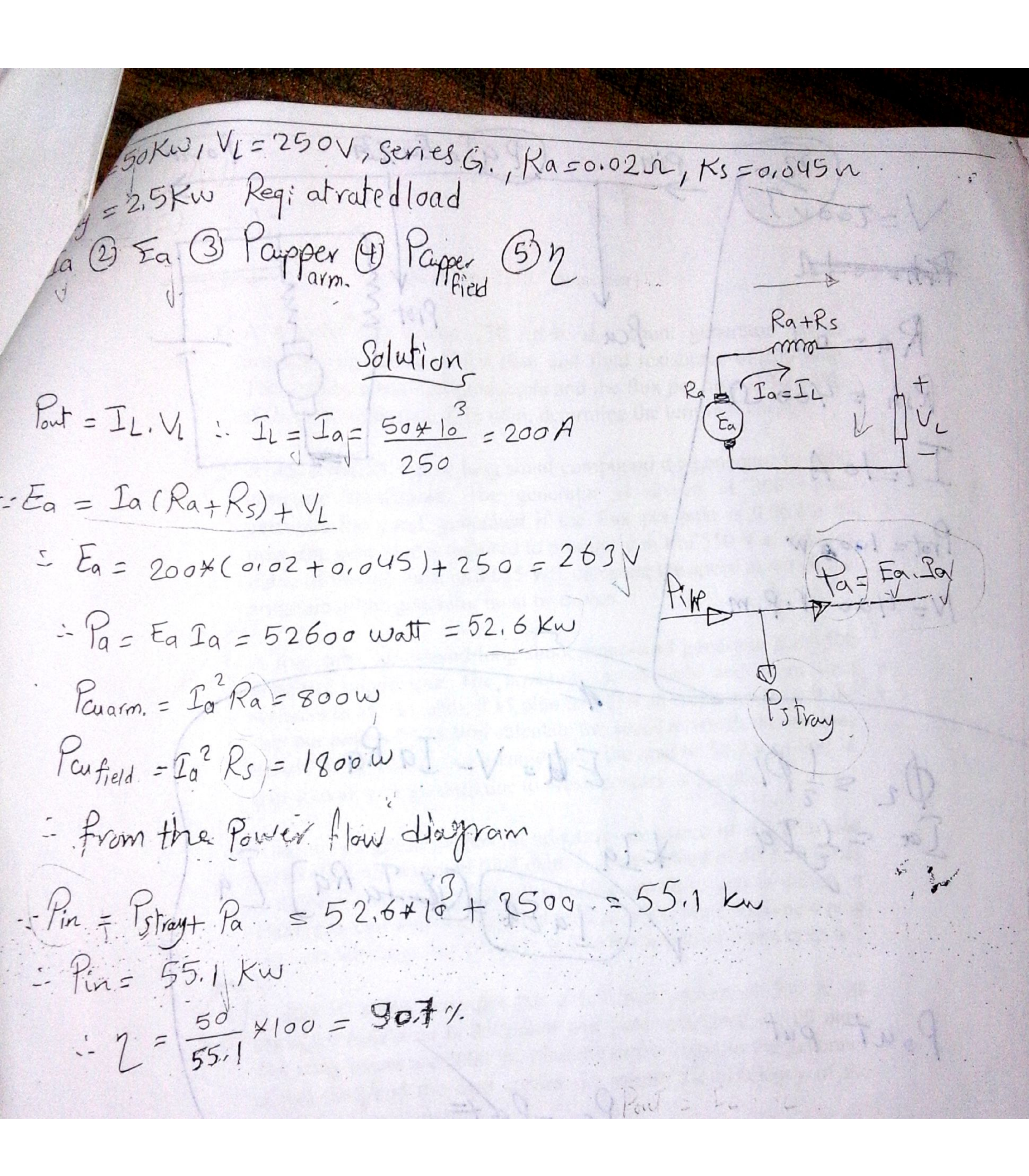
$\because P_{in} = P_a + P_{core,fri,wind}$

$\therefore P_a = P_{in} - P_{core,fri,wind} = 24.4814\,Kw$

$\because P_a = E_a I_a$

$$\therefore E_a = \frac{P_a}{I_a} = 240V$$

$$\therefore R_a = \frac{E_a - V_L}{I_a} = \boxed{0.196\,\Omega \cong 0.2\,\Omega}$$



$50 Kw$, $V_L = 250V$, Series G., $R_a = 0.02\Omega$, $R_s = 0.045\Omega$

$= 2.5 Kw$ Req: at rated load

I_a ② E_a ③ $P_{copper\ arm.}$ ④ $P_{copper\ field}$ ⑤ η

Solution

$P_{out} = I_L \cdot V_L \quad \therefore I_L = I_a = \frac{50 * 10^3}{250} = 200A$

$\therefore E_a = I_a(R_a + R_s) + V_L$

$\therefore E_a = 200 * (0.02 + 0.045) + 250 = 263V$

$\therefore P_a = E_a I_a = 52600 \text{ watt} = 52.6 Kw$

$P_{cu\ arm.} = I_a^2 R_a = 800W$

$P_{cu\ field} = I_a^2 R_s = 1800 W$

∴ from the Power flow diagram

$\therefore P_{in} = P_{stray} + P_a = 52.6 * 10^3 + 2500 = 55.1 kw$

$\therefore P_{in} = 55.1 Kw$

$\therefore \eta = \frac{50}{55.1} \times 100 = 90.7\%$

Sheet No. 2 (DC generator)

1- A 4 pole, lap wound 750 r.p.m. d.c. shunt generator has an armature resistance of 0.4 ohm and field resistance of 200 ohm. The armature has 720 conductors and the flux per pole is 30 mWb. If the load resistance is 15 ohm, determine the terminal voltage.

2- A wave wound, 6 pole long shunt compound d.c generator has 600 armature conductors. The generator is driven at 300 r.p.m. calculate the e.m.f. generated if the flux per pole is 0.06Wb. If now, the generator is required to produce e.m.f of 550 V at reduced value of flux per pole of 0.055 Wb, calculate the speed at which the armature of the generator must be driven.

3- A four pole, lap wound long shunt compound generator has 1200 armature conductors. The armature, series field and shunt field resistances are 0.1 ohm, 0.15 ohm and 250 ohm respectively. If the flux per pole is 0.075 Wb. calculate the speed at which the machine should be driven so that it can deliver the load of 50 Kw at 500 V. take overall voltage drop due to brush contact as 2 volts.

4- A dc series generator has an armature resistance of 0.5 ohm and series field resistance of 0.03 ohm, it drives a load of 50 A. if it has 6 turns/coil and total 540 coils on the armature and is driven at 1500 rpm, calculate the terminal voltage at the load. Assume 4 pole lap type winding, flux per pole is 2 mWb and total brush drop is 2 V.

5- A 400 V, shunt generator has a full-load current of 200 A, its armature resistance is 0.06 ohm and field resistance is 100 ohm. The stray losses are 2000 W. Find the power input to the generator at full load and the load current for which the efficiency of the generator is maximum.

Sheet DC generator الثاني

4 pole, Lap wound (A = P), N = 750 rpm shunt DC gen.
$R_a = 0.4\,\Omega$, $R_f = 200\,\Omega$, $Z = 720$ Cond. $\phi = 30\,mWb$
$R_L = 15\,\Omega$ Find terminal Voltage ($V_L = ?!$)

$I_{sh} = I_f$ ① I_L, I_a, R_a, $R_{sh} = R_f$, E_a, ①, $+\ V_L\ -$, R_L

$I_{sh} = I_f$, R_a, E_a, $+\ V_L\ -$, $R_f = R_{sh}$

$$E_a = \frac{\phi P N Z}{60 A} = \frac{30 \times 10^{-3} \times 4 \times 750 \times 720}{60 \times 4} = 270\,V$$

from Loop ①

$$E_a = V_L + I_a R_a = I_L R_L + I_a R_a$$

$$\therefore 270 = 15 I_L + 0.4 I_a \longrightarrow ①$$

at Node ①

$$I_a = I_f + I_L \qquad \therefore I_a = \frac{V_L}{R_f} + I_L = I_L \frac{R_L}{R_f} + I_L$$

($\frac{15}{200}$)

$$\therefore I_a = 0.075 I_L + I_L = I_L (1.075)$$

$$\therefore I_a = 1.075 I_L \longrightarrow ②$$

بالتعويض من ② في ①

$$\therefore 270 = 15 I_L + 0.4 (1.075 I_L)$$

$$270 = 15 I_L + 0.43 I_L = I_L (15.43)$$

$$\therefore I_L = \frac{270}{15.43} = 17.5\,A$$

$$\therefore V_L = I_L R_L = (17.5 \times 15) = \boxed{262.475\,V}$$

لازم يكون أقل من E_a

Wave wound , P = 6 poles , Long shunt Compound d.c gen. Z = 600
N = 300 r.p.m . if $\phi = 0.06$ wb Find Ea = ?!
if generator is required to produce emf Ea = 550V for flux $\Rightarrow \phi = 0.05$
Calculate the speed at which the Armature must be driven (N = ?!)

حل -

$$E_a = \frac{\phi P N Z}{60 A} = \frac{0.06 * 6 * 300 * 600}{60 * 2} = 540 \text{ V}$$

if $E_a = 550$ V and $\phi = 0.055$ wb , N = ?!

$$\therefore 550 = \frac{0.055 * 6 * N * 600}{60 * 2}$$

لاحظ السرعة زادت لما E_a زادت

$$\therefore \boxed{N = 333.333 \text{ rpm}}$$

(3) P = 4 pole , Lap wound (A = P) long shunt Compound d.c gen. has $\phi = 0.075$ wb
Z = 1200 , $R_a = 0.1\Omega$, $R_{se.} = 0.15\Omega$, $R_{sh} = 250\Omega$, take overall brush = 2 Volt
N = ?! if $P_L = 50$ kW at $V_L = 500$V ,

$$I_L = \frac{P_L}{V_L} = \frac{50 * 10^3}{500} = 100 A$$

$$E_a = V_L + I_a(R_a + R_{se.}) + V_{brush}$$

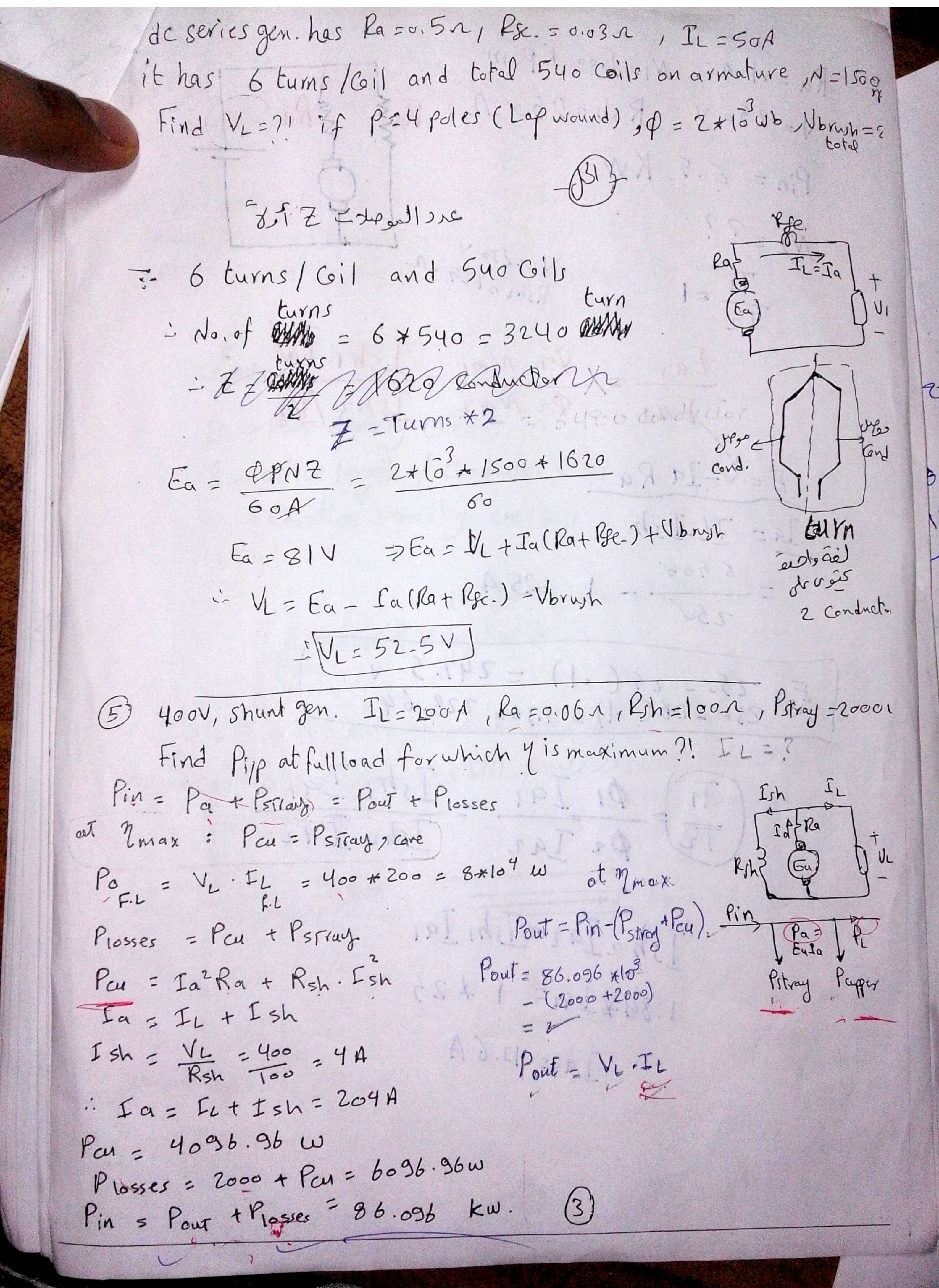
$$I_a = I_L + I_{sh} \quad , \quad I_{sh} = \frac{V_L}{R_{sh}} = \frac{500}{250} = 2A$$

$$\therefore I_a = 102 A$$

$$\therefore E_a = 500 + 102(0.1 + 0.15) = 525.5 \text{ V}$$

$$\therefore E_a = \frac{\phi P N Z}{60 A} = 525.5 = \frac{0.075 * 4 * N * 1200}{60 * 4}$$

$$\therefore \boxed{N = 350.333 \text{ rpm}} \quad \#$$



dc series gen. has $R_a = 0.5\Omega$, $R_{se} = 0.03\Omega$, $I_L = 50A$
it has 6 turns / Coil and total 540 Coils on armature, $N = 1500$ rpm
Find $V_L = ?!$ if $P = 4$ poles (Lap wound), $\phi = 2*10^{-3}$ wb, $V_{brush} = 2$ total

عدد الموصلات Z ازاي؟

∵ 6 turns / Coil and 540 Coils

∴ No. of turns $= 6 * 540 = 3240$ turn

∴ ~~Z = turns / 2 = 1620 conductor~~

$Z = \text{Turns} * 2$

$$E_a = \frac{\phi P N Z}{60 A} = \frac{2*10^{-3} * 1500 * 1620}{60}$$

$E_a = 81V \Rightarrow E_a = V_L + I_a(R_a + R_{se}) + V_{brush}$

∴ $V_L = E_a - I_a(R_a + R_{se}) - V_{brush}$

∴ $\boxed{V_L = 52.5V}$

(5) 400V, shunt gen. $I_L = 200A$, $R_a = 0.06\Omega$, $R_{sh} = 100\Omega$, $P_{stray} = 2000$
Find $P_{i/p}$ at full load for which η is maximum?! $I_L = ?$

$P_{in} = P_a + P_{stray} = P_{out} + P_{losses}$

at η_{max} : $P_{cu} = P_{stray}$, core

$P_{o\,F.L} = V_L \cdot I_{L\,F.L} = 400 * 200 = 8*10^4\ w$ at η_{max}

$P_{losses} = P_{cu} + P_{stray}$

$P_{cu} = I_a^2 R_a + R_{sh} \cdot I_{sh}^2$

$I_a = I_L + I_{sh}$

$I_{sh} = \frac{V_L}{R_{sh}} = \frac{400}{100} = 4A$

∴ $I_a = I_L + I_{sh} = 204A$

$P_{cu} = 4096.96\ w$

$P_{losses} = 2000 + P_{cu} = 6096.96w$

$P_{in} = P_{out} + P_{losses} = 86.096\ kw.$

$P_{out} = P_{in} - (P_{stray} + P_{cu})$

$P_{out} = 86.096*10^3 - (2000 + 2000) = \checkmark$

$P_{out} = V_L \cdot I_L$

(3)